DOCUMENT RESUME

ED 178 308 SE 029 033

AUTHOR	Petty, Mary Clare
TITLE	How To...Record and Use Data in Elementary School Science. Revised Edition.
INSTITUTION	National Science Teachers Association, Washington, D.C.
PUB DATE	75
NOTE	12p.; Not available in hard copy due to copyright restrictions
AVAILABLE FROM	National Science Teachers Association, 1742 Connecticut Ave., N.W., Washington, D.C. 20009 (Stock No. 471-14292; $1.00, discounts on quantity orders)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Data Analysis; *Data Collection; Educational Resources; Elementary Education; *Elementary School Science; *Inquiry Training; Instructional Materials; Learning; Measurement; *Process Education; *Recordkeeping; Science Education; Science Instruction; Skill Development
IDENTIFIERS	National Science Teachers Association

ABSTRACT

Data collection and recordkeeping are the topics discussed in this instructional aid. Examples are given of creative ways of recordkeeping developed by children. Justification for the process is presented, such as the kinds of skills that can be developed by keeping science records. The evaluation of childrens' work is discussed and suggestions are given for making use of the records. References are also included. (SA)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

NATIONAL SCIENCE TEACHERS ASSOCIATION

how to...

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

"PERMISSION TO REPRODUCE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY

NSTA

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

RECORD AND USE DATA

in elementary school science

Mary Clare Petty *Associate Professor of Education/University of Oklahoma*

ED178308

The elementary school science program should provide many opportunities for children to develop and use science records. Records are essential to scientific inquiry, and when science experiences provided by the elementary school are genuinely scientific, they include the use of records. Specifically, records are data; and data are needed before operational patterns can be discovered and generalizations drawn.

Why should children develop and use science records?

Major goals of science education and the structure of science justify the development and use of science records by children in the elementary school. Moreover, such practice is efficient and in complete harmony with the characteristics of children and the nature of the learning process.

Educators are deeply concerned about the responsibility of the school for the development of the rational powers of children. They generally agree that the goals of science instruction should be those that teach *inquiry process* and provide the learner with tools for independent learning. The emphasis has shifted from acquiring isolated facts to an understanding of how these facts are acquired and to the development of skill in inquiry. Only as children engage in inquiry can they develop their rational powers. Recording data is usually an integral part of inquiry.

Current learning theory and Piaget's theory of children's cognitive development have profound implications for instruction. Children learn only as they interact with their environment: with things, people, and ideas. Learning is an active process, the result of the learner's responses. The thinking of the young child largely centers around the mastery of symbols, and the child of five or six years of age is concerned with manipulating objects on an intuitive level rather than by thinking about them. About the time he enters school, dramatic changes in his thinking begin to evolve. However, he still may be capable only of thoughts about the concrete, existing people and objects, not about dealing with his own thinking or with abstract theory. He is able to manipulate mentally concrete experiences that previously had to be physically manipulated. Children designing, developing, and using science records are interacting with their environment in a highly meaningful and productive manner.

Instruction must encourage and facilitate the transfer of learning from one context to another and develop the ability and willingness to give thought to new problems. The child must *learn to learn*. Involvement in inquiry, including recording data, is the foundation for instruction for transfer.

What are records?

For the purpose of this discussion, records are notations about events or observations, which elementary school children have put into some form for future use as a part of their study of science. This definition is broad enough to cover the simple picture of the sun drawn by a kindergarten child on a calendar to indicate the type of weather for the day or the relatively sophisticated set of graphs worked out by a sixth grader to summarize temperature and rainfall information. In the same way, the simple labels put on a wild flower collection by first-graders, the carefully kept list of birds identified in the community by third-graders at different seasons, and the raw data set down in writing by sixth-graders studying pulleys are all records.

Records may be developed as guides for further study, to provide information leading to new methods or techniques for an experience, to test a hypothesis, to allow duplication of an experiment, to make simple predictions, or simply to convey information. A chart prepared by a sixth-grade class to summarize information about the planets might have as its primary purpose the communication of this information to another class or to parents; the record of observations made by children on falling balls might serve to evaluate their hypothesis that a heavy ball falls faster than a lighter one; a list of sources of information prepared by another class

SE 029 033

©National Science Teachers
Association 1965
Revised 1975

Stock No. 471-14292—Price $1

Discount on quantity orders: 10 percent, 10 or more copies. Payment must accompany all orders except those on official purchase order forms. Postage and handling charges will be added to billed orders. Prepaid orders over $1 include 50¢ postage and handling.

Order direct from NSTA
1742 Connecticut Avenue, N.W.
Washington, D.C. 20009

might be used to facilitate a study of prehistoric plant life; or the record made by children of their practices in raising a hamster might lead to better practices if some have proved unsatisfactory.

What types of science records are appropriate for children's use?

Children should be encouraged to approach record keeping as a challenge to their imagination, and if they approach it creatively, they will suggest ideas for records that would not appear in any list of possible types of records. An excellent example of this is the way in which some children solved a problem in record keeping. They wanted an accurate record of the growth of some plants. Periodically they cut off strips of paper exactly the length of each plant, labeled, dated, and carefully filed each strip. Later the strips were pasted on a large piece of cardboard to form a graph. Would a teacher have thought of recording plant growth in just this way?

A list of types of records is given on page 4. Any such list can only be suggestive, and it will be incomplete and include overlappings. For instance, the record described above might be considered a graph, a record of sequence, or a record of raw data of observations. Most data can be presented in many different ways, and the teacher must guide children as they select the form of record most appropriate for a specific purpose. One significant criterion to be used in making this selection is the interest of the children. Any record used should hold high interest and motivational value for children. Closely related to the factor of interest are the skills and maturity of the class, for children should experience success as they develop and use science records. Children should have opportunities to perfect previously introduced recording skills and master additional ones. Any form of record selected should be simple enough to be used by the children with ease and satisfaction.

Although children should develop as high a level of mastery as is practical for their maturity, the excessive use of any one type of record results in a minimum of learning. Frequently, children who have become confident in their use of a few forms of records have to be prodded by the teacher to try new ways to record data and gain mastery of new skills. The teacher must balance practice and new experiences.

Any record should be appropriate in terms of the data to be presented and the purpose it is to serve. Children can be guided to understand, for example, that much data expressed numerically can be presented in charts or graphs, that many relationships are appropriately shown in diagrams, and that pictures can communicate details of visual observations. Children can also be guided to understand that the same information may be recorded in a list of simple statements for class use, or in a series of charts with illustrations to share with others; that much raw data may also be recorded in a temporary form for immediate use while a glossary of terms is better put into a more permanent form to facilitate its repeated use.

As the teacher makes decisions about the best form of record to use for a specific purpose, he should also consider the practicality of efficiency of a record. He should give special attention to the time different forms require for preparation and to the availability of materials. The child's time in school should always be spent in the best possible way, not just in a good way.

What purposes for keeping science records can children understand and accept?

Children can and should have clear purposes for the science records they keep. Their use of records cannot be effective, and the teacher's purposes cannot be attained if the children do not un-

derstand and accept significant purposes for the records they develop. The purposes held by the teacher and by pupils will not be identical but must be in harmony if the recording experience is to have maximum significance for the children. Children should therefore be encouraged to express their own reasons for keeping records. Although their statements will reflect their depth of understanding and their maturity, even the youngest children in the elementary school are capable of keeping records with clarity of purpose and should be given an opportunity to express their reasons in their own way. Children might say in effect:

"We keep records because
. . . we do not want to forget some information
. . . we must be very accurate about some facts
. . . records may help us ask 'good questions'
. . . we may find it important to check some information in different ways
. . . records may help us find answers to some of our questions
. . . they may help us explain some facts
. . . we want to summarize some information
. . . records help us share some information
. . . often lots of individual facts help us to find a really big idea."

Children are interested in records that concern their own growth.

Alyce Jackson

How should a teacher evaluate children's experience with science records?

The teacher should evaluate continuously the experiences children have as they design, develop, and use science records. Evaluation helps the teacher assess constructively the concepts, abilities, skills, and interests of children. The questions listed below imply criteria which the teacher should use as he guides children's experiences with science records.

What are the children learning from keeping this record?

They should be learning desirable attitudes and should be developing skills, and understandings of the processes of science. Such learnings are much more important, particularly for that age group, than mastery of specific information. Does the record help children to observe, to evaluate and classify data, and to develop and test hypotheses? Children should not be asked to keep a record that does not contribute to the realization of major objectives of science education.

Is the form of the record appropriate for the level of maturity of the class?

Keeping a record should challenge children and lead them to new learnings. A record that is too difficult or time-consuming, however, may discourage children. Records should be simple enough that the children may keep them with relative independence.

Is the form of the record appropriate for the kind of data being considered?

Each form of data processing has its unique uses. Children will recognize this fact only if the forms of the records they keep are appropriate for the information being recorded.

Is the record accurate and complete enough to present all the essential information?

Children's records must be complete and accurate if these records are to help the children solve problems. Children may fail to identify important variables or to discover important relationships when pertinent data are not included in their records.

Is the record an efficient way of presenting the information?

The efficiency of a record must be evaluated in terms of the use that is to be made of it and the demands it makes upon classroom time and resources. A record that is to be used many times may be put on poster paper with a lettering pen while information that will have little importance after its initial use may be recorded on the chalkboard or newsprint. A record that is to be shared with others should be attractive even if making it attractive demands time and effort.

Are the children interested in this record?

Interest shown by children in an activity is an excellent index of the significance of that activity. Obviously, however, interest is only one criterion and must not be used alone.

TYPES OF SCIENCE RECORDS

Labels and Lists	of collections, specimens, parts of plants, parts of diagrams . . . of birds, plants, shrubs in community . . . of materials needed for experiment . . . of objectives or purposes . . . Lists may be very simple or relatively highly organized, showing classifications and/or relationships.
Pictures and Symbols	of smiling suns, rotund snowmen on weather records, of parts of plants we eat, drawings of "signs" of winter or spring . . .
Diagrams	of parts of a simple machine, location of trees in park, plans for a spring garden, relative size of planets, set-up of apparatus for an experiment . . . Diagrams may be copies or originals.
Graphs	of numerically expressed data: rainfall, temperature, relationship of height and weight, proportion of different gases in air, a balanced diet . . . Use of line graphs, bar graphs, circle graphs, and pictographs should be developed.
Tables and Charts	of information about geologic eras, or the force needed to lift a weight with three different arrangements of pulleys, or the description of temperature zones . . .
Records of Sequence	of care and development of small animals, or development of eggs in incubator, growth of plants used in experiment, observations of changes in moon over period of weeks, water level in dishes during evaporation studies . . .
Simple Memoranda	of details about care of pets or plants in the classroom, plans about future activities, responsibilities accepted, ideas and theories to be checked later. The memoranda may be incorporated later into more complex forms of records; they insure accuracy of recall and minimize oversight of significant information at a later date.
Records of Raw Data of Observations	of elements of time, selection of appropriate units of measure, approximate nature of all measurements, weights pulled by pulleys, length of time candles burn in containers of different sizes, measurements of the same surface obtained by different children, temperature at which they find water boils . . . *Children must be encouraged to record raw data they obtain and not what they believe these data should be.*
Narrative and Descriptive Records	of accounts by the class, with teacher serving as "secretary," following a trip to a zoo . . . of a visit to a resource person or a discussion stimulated by an article in the newspaper . . . These reports are not "unscientific" and can stimulate interest, raise questions, and help in identification of valuable scientific problems for study.
Tape Recordings	of use for narrative and descriptive records. Tape recordings allow more freedom to the children, who can concentrate better on *what* they have to say. Playback may be followed by discussions and lead to questions such as: "Why did we say that?" "Is this a reasonable statement?" Recordings may be used to explain diagrams or models, supplement pictures and drawings . . .
Reports in Three Dimensions	of models of cross section of earth's crust or an oil well . . . of the solar system, collections of leaves and bark, displays of seeds in different stages of germination . . . Three-dimensional reports make concepts more vivid, accurate, and meaningful.
Formal Reports of Experiments	of actual results obtained by the children in their experiments. Experience with formal reporting makes for "scientific literacy" and prepares the students for the type of records expected of high school students.

Do the children have a purpose for keeping this record?

Children must always have a purpose for record keeping if the experience is to be significant for them. Children should not keep a record just to please a teacher or because they are told to do so.

Have the children had a major role in working out the design of the record?

Children should be involved in the designing of records whenever possible. They approach record keeping enthusiastically, creatively, and with purpose when they are involved in the planning stage.

What criteria for evaluating records can children understand?

If the full learning potential of keeping and using science records is to be realized, children must mature in their capacity to evaluate their records, and they can learn to do this best in terms of criteria they work out themselves. Children should, therefore, be led to set standards for evaluating their science records.

Just as the teacher must lead children to accept purposes which are in harmony with his purposes, he should also lead them to develop criteria which are in harmony with his criteria. These criteria should be closely related to the purposes the children have for keeping the records.

Putting evaluative criteria in the form of a chart is useful. All elementary school classes are capable of making clear, concise, cooperatively developed, and readily available statements of criteria for evaluating science records.

The teacher's role as he guides children to state their own criteria is simple but important. First the problem must be presented to the class, such as: "What criteria should we use as we evaluate our science records?" of "Is this a good science record—Why?" All suggestions children make should be accepted and recorded, probably on the chalkboard. Each statement should then be criticized and accepted or rejected by the class. The next step involves editing. Children should consider such matters as the clarity of ideas, the duplication of ideas, the forms the criteria should take, and the way each individual criterion is stated. Finally the criteria are recorded for future use. This process is not very time-consuming, and the criteria should serve as a basis for evaluating many different records even if the specific reason for keeping each record must be established. If through oversight an important criterion is overlooked, it is often better for the teacher not to bring it up but to allow the children to discover it later through their own use of records.

Some of the suggestions children might make from which criteria could be formulated are:
A good science record has a purpose.
A good science record is accurate.
A good science record is easily understood.
A good science record is well organized.
A good science record is efficient.
A good science record should be attractive.

Different classes will express criteria in very different ways and will show different levels of maturity. A class might combine some ideas, add others, or omit some. The criteria might be expressed as questions, as statements, or as descriptive phrases.

What skills can keeping science records develop?

Children can learn specific skills as they develop and use science records. Some of the skills significantly related to the objectives of the elementary school science program are observing, selecting and evaluating data, classifying and organizing data, using units of measure, using graphs and tables, formulating and testing hypotheses, and designing simple experiments. There is a dual relationship between keeping records and the development of these skills. On the one hand, recording gives the children an incentive to develop these skills and gives insight into their importance. On the other hand, recording actually gives them opportunities to practice these skills.

Observing

Teachers should stimulate children to be interested in and alert to their environment, to develop the habit of "seeing what they look at." Science records can make two contributions to the achievement of this goal.

The first stems from the fact that children who have become interested in keeping a record are motivated to observe, for they have a reason for making careful observations. For instance, a record can lead children to become excited about the changes all about them. Weather, erosion, clouds, stars, and chemical changes may take on new meaning and attract children's attention in a new way. Recording can be more effective than oral sharing, for recording gives new meaning and significance to observations. There is genuine stimulation in a child's realizing, "This is important enough to record!"

The second contribution to maturing the observational skills of children stems from the fact that skill in making observations develops through practice. When children are encouraged to keep records, they become not only more avid observers but also more accurate and critical observers. Keeping records also helps a child to know what to look for and to appreciate the problems of accuracy in description.

Selecting and evaluating data

Children learn to give careful attention to pertinent data and reject data which are not relevant when they develop science records with purpose and direc-

A lamb kept by the class is fed . . . and weighed before and after meals.

tion. Recording can stimulate a child to ask questions such as: "Is this event significant?" "Is this finding related to our problem?" "Will these data help solve our problem?" "What does this discovery mean?" Asking himself these questions, he realizes that his classmates will ask similar questions before they decide to record their observations. A child must decide WHAT to record, and he grows with every observation-recording experience.

Children developing a weather record may become more selective as they decide at what time each day temperature should be recorded and where the readings should be made. Even the kindergarten pupils writing a story about a caterpillar or a goldfish must select from their many observations those that are to be recorded in the story. These are simple examples of the way recording can help children become more skilled in selecting and evaluating data.

A science record can also keep a science lesson from degenerating into little more than an interesting discussion of loosely related information, "a glorified show and tell." The fact that a record is being kept gives the teacher a technique to pull children back into a more purposeful consideration of a problem.

Organizing data

Record keeping gives children a powerful incentive to organize facts. A group inclined to consider a subject in a rather disorganized manner can see the importance of organization when it faces the problem of keeping a record. Properly organized records focus attention upon relationships and classification, which is an important aspect of many records as well as one of the rational powers which should be developed in children.

For instance, as simple a project as labeling a rock collection or displaying seeds focuses attention upon classification. Children are forced to consider the problem of organization and to compare, classify, evaluate, recall, and imagine, when they attempt to put a wealth of information about planets, for instance, into chart form.

Understanding and using units of measure

One of the most significant contributions of record keeping is to add to children's appreciation of problems of measurement. Nothing is as effective in helping children understand the nature of measurement as experiences in making measurements. The desire to keep accurate records gives a real reason, recognized by the children, to make appropriate and accurate measurements. As children become involved in recording data, they have rich experiences in practical applications of units of measure which help them develop objectivity, exactness, and understanding of the problems involved in achieving these goals.

As the teacher guides the children in their recording of data in terms of units of measure, he should make them aware of (1) the reasons for making measurements, (2) the nature of a unit of measure, (3) the relation of different units of measure of a similar nature, (4) the importance of selecting the most appropriate unit of measure for a given purpose, and

The lamb's weight is recorded . . . and its weight increases shown on a chart.

Vernon Brugger, Indiana University School

(5) the approximate nature of all measurements. If the teacher is to be effective in helping children realize these goals, he must give special attention to the evaluation of the records by the children in the light of the criteria or standards set up by them. This facet of record keeping is of special significance because it tends to bring certain aspects of science and mathematics programs closer together and break down the artifical but traditional separation of these two areas of the elementary school curriculum. Children in elementary classrooms have many opportunities for making measurements as a part of their record keeping. Even very young children keeping a weather record are not content with describing the weather as "hot" but recognize the need to record "how hot" the weather is. Children working with comparing the strengths of two magnets can use their own units of measure. For example, the children may find that one magnet will pick up 18 paperclips while the other one may only pick up 10 paperclips. If the children are working with iron filings they can compare magnet strengths by scraping off the iron filings and weighing them. The fact that records will have to be kept on the magnet's strength will be extremely important because the children will have to develop a system which can be understood and used.

Another important concept can also be learned by children: control of variables. Children carefully measuring and recording the amount of water given to two or more plants which have been planted in different soils, then recording the growth of the plants under these variable conditions, grow in their understanding of the importance of control of variables and the contribution measurements can make to such control. They also appreciate the importance of the selection of an appropriate unit of measure and the approximate nature of all measurements.

Using charts, graphs, and tables

Not only are charts, graphs, and tables important tools used by the scientist to present technical data, but the use of these forms by mass media of communication is increasing. This fact underscores the need to develop skill in interpreting such data-presentation methods. As children use charts, graphs, and tables in their own science records, they develop increasing skill in interpreting data presented in these forms by others. Record keeping can lead to more effective interpretation of materials such as reports of agencies, charts and graphs in print, weather information in newspapers, and science reports in magazines. It is conceivable that a whole generation could be developed that would read rather than skip charts, graphs, and tables if adequate attention were to be given to this aspect of record keeping!

The interrelationship of science and mathematics is being emphasized anew. Several modern science and mathematics programs have been developed by scientists, mathematicians, and educators working cooperatively. They emphasize the development and interpretation of charts, tables, and graphs. When

these important data-processing techniques are an integral part of both programs, the two are brought together in a very functional manner. A primary class, for example, may be given the following problem as part of the mathematics program: "Mary walks five blocks north from home, then five blocks east, then five blocks south, and then five blocks west. Draw a way on the grid showing her route." The same students may also utilize this kind of graph during their study of a science unit on "Direction and Distance." In another elementary classroom, the teacher may "have each child in his mathematics class construct a bar graph on which he records his weekly spelling scores for a six-week period," and also have him use bar graphs to record "changes in snail population" which is being studied as part of the science program. As part of the mathematics program, another class may be introduced to "the idea that the location of sets of points in a plane can be described by the use of reference lines and numbers which are called coordinates." The same class may be expected to "construct a table or graph of temperature and time" as part of a study of "Temperature and Heat Energy." In all three classrooms, children are having experiences which tend to integrate science and mathematics instruction and which help them understand the relationship between these two disciplines.

Formulating and testing hypotheses

Directing children's natural interests and curiosity in such a way that they are led to ask "Why?" is essential in effective science instruction.

Records play a very important role in stimulating children to ask the important question "Why?" The relationship is clear and simple. Accurate, significant, factual information recorded by the class is a potent, natural stimulus leading to questioning. As a child keeps records of experiments simulating the effect of grass cover and dams on erosion, for instance, he may begin to think: "What do these facts tell us? Are the facts related? Do they have a common explanation?" This thinking is the first step in the process of formulating hypotheses. The next natural step is to suggest a possible answer or to say, "MAYBE this is the reason." Next an even more mature question may be asked: "How can this explanation or this MAYBE be checked?" This is the process, slightly oversimplified, of hypothesizing, which may lead, in turn, to further experiments. The teacher who "gives" the answers to children's questions of "Why?" or, even worse, who is guilty of giving the explanations before the questions are asked, robs children of the opportunity to develop rational processes.

It is highly beneficial to stimulate even the youngest children to seek explanations and to welcome even the weakest attempts to formulate hypotheses. Records may be thought of as a very important part of *establishing readiness* for the process of theorizing, and teachers should understand the importance of developing such readiness. When children are given time to ask questions without fear of being misunderstood and when their questions are received with respect, they will naturally proceed to questioning, to theorizing, and to testing.

Children must be led to understand that any "maybe" or hypothesis formulated should be carefully tested and that this can be done by exploring books in the school or home libraries and finding reported verification of the hypothesis or by designing and carrying out their own experiment to test it. They should have experience in testing hypotheses in both ways. The use of the first method is restricted by the library skills of elementary children and the limited availability of appropriate printed matter in elementary schools. Nevertheless, children should be given every possible opportunity to search through the available literature. The second method for testing a hypothesis has much broader application in the elementary school program. Children need to be consistently encouraged to design and conduct experiments to test their hypotheses.

Consider the following case: A class of young children experimented with a heterogeneous collection of objects and some magnets. They recorded their results, listed the objects, classified and reclassified them according to one or another physical characteristic, trying to find some order among them. Looking over their notes, they finally realized that magnets pick up only some metal objects. The children then proceeded to test metal and non-metal objects with magnets before accepting the hypothesis. If these young children had not experimented on their own and kept the very simple records of objects their magnets picked up, they would very probably not have been stimulated to develop and check this hypothesis. How very much wiser it was for the teacher to permit the students to "discover" this fact than it would have been to "give" them the answer.

The formulation of hypotheses may also lead to predictions. A class, for instance, was able to predict with remarkable accuracy the amount of daylight there would be for weeks in advance through the use of a graph it made. Making a prediction by extrapolation from a graph was a direct outgrowth of the science record which the class developed.

Designing simple experiments

Designing and carrying out simple experiments might well be considered as the very climax of activities provided by the modern science program on any level in the elementary school. Modern science teaching stresses the spirit of discovery and must provide many opportunities for children to conduct experiments they themselves design.

By evoking wonder and curiosity, records lead to the identification of problems and aid in efforts to de-

A three-dimensional display of objects attracted and not attracted by magnets.

sign and conduct simple experiments to solve these problems. Without data and experience in handling them, children cannot "discover" solutions to the problem being investigated or to many other problems. Obviously, there can be no problem solving without concern about the problem. Children of all ages in the elementary school are completely able to identify and state simple problems if they have objective, well-organized data to stimulate them. Data that children have incorporated into their own science records hold maximum interest and meaning for them and are more likely to lead to experimentation than are data processed by others.

After the problem has been identified, records are again helpful as the children attempt to design experiments because the raw data in records are the "stuff" from which hypotheses to be tested by experimentation are derived. Without information, theorizing is impossible; and poorly focused, "hazy" information can lead only to weak theorizing. Records help children (1) identify important variables, (2) recognize needed controls, (3) select appropriate and efficient units of measures to be used in evaluation, and (4) select or design appropriate apparatus for experimentation.

Look at this example which occurred in an elementary school: Boys and girls, working with a meter stick delicately balanced on a fulcrum, suspended different weights on hooks at varying distances. Their observations and records stimulated them to hypothesize that the weight times distance on one side of the fulcrum equaled the weight times distance on the other side of the fulcrum. Working with the data they had recorded, the children discovered that their theory was not confirmed by their data. Yet the data so nearly fitted their theory that they refused to discard it without further study. Additional inspection of their records led them to realize they had not recorded the weights of the hooks attached to each side of the meter stick. With this insight they were able to verify their hypothesis. The records kept by these boys and girls played an important part in the successful formulation and testing of a hypothesis.

Teachers should not always make readily available the apparatus children need for an experiment. Selecting and/or designing the apparatus needed is in itself a valuable experience in problem solving. A clear understanding of the problem is essential to the selection of appropriate equipment for any experiment, and records children keep may help to develop such understanding. Reading notes and records of simple observations or the records of an unsuccessful experiment may help to clarify a problem and lead to planning further experimentation, including the selection or designing of equipment.

Record keeping can also lead children into depths of questioning and experimentation that even experienced teachers would not anticipate. A class studying substances in solid, liquid, and gaseous states made a written record classifying common substances according to these three states. The fact that ice, water, and water vapor appeared on their record attracted the children's attention and led to an interest in changes of water. During the consideration of this topic, a child suggested that water expanded with freezing. This observation, an outgrowth of the study of a very simple record, led to a series of valuable experiences. The class began a study of all related literature that was available and verified successfully the fact that water did expand with freezing. Consideration of this fact led to the question as to whether or not water changed in weight with freezing. Library research did not answer this question. Finally the boys and girls designed their own experiment and weighed many samples of water in both liquid and solid form. It required perseverance and resourcefulness to find ways to do this: They secured the cooperation of the neighborhood pharmacist who provided adequate scales and instruction in their use; and the cafeteria manager made the use of a refrigerator possible. During the conduct of their experiment, keeping records was again necessary before any conclusions could be drawn. Would the children have obtained such valuable experiences if their study of the original problem had been limited to reading and oral discussion?

What uses should be made of the records children develop?

Since records should always be considered means to ends rather than ends in themselves, teachers should be consistent and conscientious in having children use the science records they develop. Science records which are not used become uninteresting and insignificant to the children who develop them, for only through the use of their own records do children gain respect for, and understanding of, the role of records in scientific inquiry.

A teacher gives constructive guidance as a child learns measurement.

Phyllis Marcuccio

But the most significant uses children can make of records are those directly related to the purposes set up for the records by the children themselves. In addition, teachers can and should stimulate additional uses of records not initially recognized by the class. Teachers should encourage children to use their records to review, summarize, or check accuracy of recall. Records should also serve as a resource file of information, be used to share information with others, and help in the identification of important aspects of a problem.

What are some possible misuses of record keeping?

Certain undesirable practices may be associated with the development and use of science records. Some of the more common practices are listed below.

These few warnings should not discourage any teacher, for most teachers and children enjoy and profit from their use of science records. Fortunately the usual insight and instructional skill of teachers insure constructive guidance as children develop and use science records.

Record keeping must not be imposed upon children. They must accept the activity as a highly important one. Although teachers should initiate plans for keeping some records, too many "assign" records, and these records become "chores" to the pupils and may cause children to dislike science.

The form records take should not become stereotyped. Unfortunately reporting experiments in a highly structured form is the only experience with science records that some pupils have. Such practice leads to boredom and resentment and may be described as little better than "busy work." This practice defeats most of the purposes for keeping science records because children become primarily concerned with putting down "what the teacher wants." Teachers should become disturbed when children ask, "What do YOU want?" One answer might be, "Whatever YOU have found out in your experiment."

Record keeping should not primarily represent teacher activity. All records should be simple enough for pupils to have a major role in their development. Too many attractive and very adequate science records are the result of the work of the teacher. Such records may be valuable instructional aids, but they are not truly the children's science records and most certainly do not contribute to the development of the children's rational powers.

A record should not become an end in itself. This is a fact that teachers forget too easily. Well-designed and executed records can afford such satisfaction that both teachers and pupils frequently lose sight of their real function. Unfortunately a record may become an efficient technique for keeping children superficially interested, for making the classroom more attractive, or for favorably impressing parents, administrators, and supervisors.

The children's experiences should not be such that they learn to equate records with testing devices used by the teacher for purposes of "grading." Certainly science records kept by children furnish valuable information for evaluation of pupil growth, but children should not be allowed to become concerned primarily with the "grade" that a record will receive. Records developed and evaluated cooperatively are seldom misused in this way.

The teacher should not overprotect the pupils against mistakes made while they keep science records. Sometimes a record which does not provide the information needed to solve the problem can help children grow in understanding. "We wish we had done it this way" or "Next time, let's . . . " shows insight and developing maturity.

A record should not become a major determiner of classroom activities. Keeping records that are complicated and time-consuming may result in highly structured lessons and may discourage informal class activities which foster initiative and creativity. A record should not take away time which might be better given to other activities.

Science education today

Science teaching has changed. Today science education is emphasizing the process of knowing and accepts responsibility for helping children develop their rational powers; inquiry is the instructional strategy common to successful science programs; and record keeping is an essential element of inquiry. Many elementary school children, including kindergarteners, are engaging in genuine inquiry, and their teachers are enthusiastic about the outcomes. Their enthusiasm and success and the relative simplicity of the whole task should encourage other teachers to provide children with more opportunities to use records as an integral part of science inquiry. Teachers who have been hesitant to provide such experiences in their classrooms should experiment with record keeping, for they can enjoy the success other teachers are having, strengthen their science programs, and have the satisfaction of watching children develop mastery of the processes as well as the content of science.

REFERENCES

Educational Policies Commission. *The Central Purpose of American Education*. The National Education Association, Washington, D. C., 1961.

Gorman, Richard M. *Discovering Piaget, A Guide for Teachers*. Columbus, Ohio: Charles E. Merrill Publishing Company, 1972.

Renner, John W., and William B. Ragan, *Teaching Science in the Elementary School*. New York: Harper and Row Publishers, 1968.

Renner, John W., Gene D. Shepherd, and Robert F. Bibens. *Guiding Learning in the Elementary School*. New York: Harper and Row Publishers, 1973.

Children transfer records of plant growth to simple charts.

Chris Pouler

OTHER TITLES IN THE SERIES

How to Teach Measurements in elementary school science (471-14580) Neal J. Holmes and Joseph J. Snoble $1

How to Use Behavioral Objectives in science instruction (471-14596) John J. Koran, Jr., Earl J. Montague, and Gene E. Hall $1

How to Use an Oscilloscope (471-14572) Morris R. Lerner $1

How to Evaluate Science Learning in the elementary school (471-14564) Paul E. Blackwood and T. R. Porter 35 cents

How to Care for Living Things in the Classroom (471-14288) Grace K. Platt 50 cents

How to Plan and Manage Minicourses (471-14648) Joseph Barrow and John W. Lakus $1

How to Investigate the Environment in the City: Air and Water (471-14630) David C. Cox 50 cents

How to Read the Natural Landscape in Forests and Fields (471-14618) Millard C. Davis 50 cents

How to Present Audible Multi-Imagery in environmental ecological education (471-14614) Pascal L. Trohanis 50 cents

How to Study the Earth From Space (471-14624) Robert E. Boyer $1

How to Tell What's Underground (471-14640) Rolland B. Bartholomew $1

Others in preparation. Consult your NSTA publications list. Order direct from NSTA, 1742 Connecticut Ave., N.W., Washington, D.C. 20009. Discounts: 10 percent, 10 or more copies. Payment must accompany all orders except those on official purchase order forms. Postage and handling charges will be added to billed orders. Prepaid orders over $1 add 50 cents postage and handling.